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CONTENT

3d facies analysis based on well data with different geostatistical and sedimentological approache

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ABSTRACT

The main aim of this work is to determine the depositional environment of a potential reservoir body, which has been developed in a Late Miocene (Lower Pannonian) turbidite system, through the lateral extension of facies in macro-scale. According to the actual stage of this work, the area can be identified as a Mud/Sand-Rich Ramps. The input database was built from measured and interpreted well data such as corrected spontaneous potential (SPC), gamma-ray (GR), porosity (PHI) and shale content (VSH). The first step was the identification of the well-log-shapes in the target reservoir for using the indicator kriging to reveal the possible lateral connections between wells in each categorical variable. The indicator kriging was chosen because it could be show the probability for all categories. The second stride was the variography of the predefined well shapes as indicator variables. For the appropriate interpretation, a widely accepted additional workflow was used that contains the spatial distribution of the lithology ratios. The ratio of the sandstone/non-sandstone lithology was able to reveal (1) the presence or absence of channels which had taken an important role in the depositional history, and (2) the lateral movement of the depositional system.

Key words: *variography, indicator kriging, uncertainty, spatial distribution, well logs*

1 THE STUDIED AREA

The field is located in the centre of the eastern region in Hungary. The target reservoir is a member of a bigger reservoir group in the Late Miocene (Lower Pannonian) turbidite system.

2 DATA AND METHODS

In the study area 28 wells were drilled (**Figure 1**). Two wells (5.;11. in **Figure 1**) were ignored since they were too far from the others. In each well spontaneous potential (SPC), gamma-ray (GR), porosity (PHI) and shale content (VSH) were available for well log response analyses.

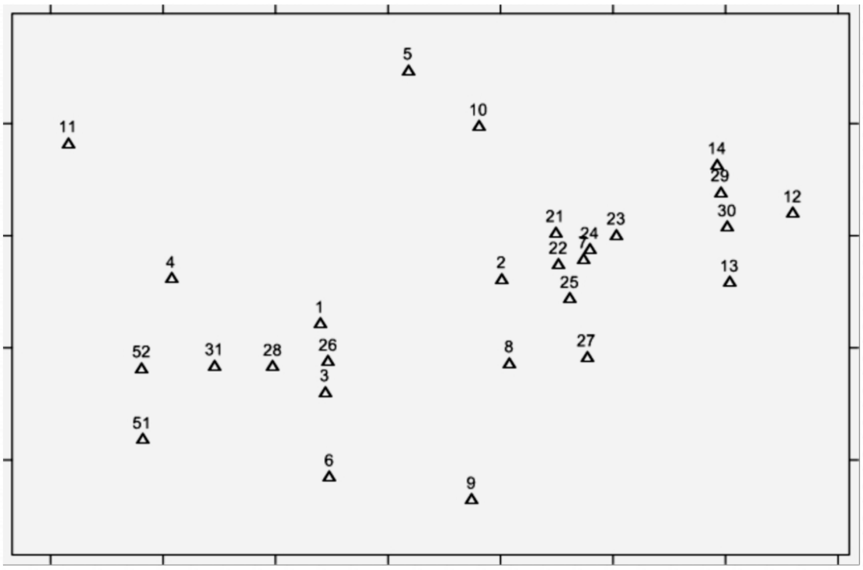

Figure 1: *Location map*

Figure 2 shows the spatial distribution of the reservoir thickness. As the map illustrates the thickness was continuously increased towards from the West and northwest part to the South and southeast region. The thinner parts, with less than 12 meters of thickness, were connected to higher relief of the basin.

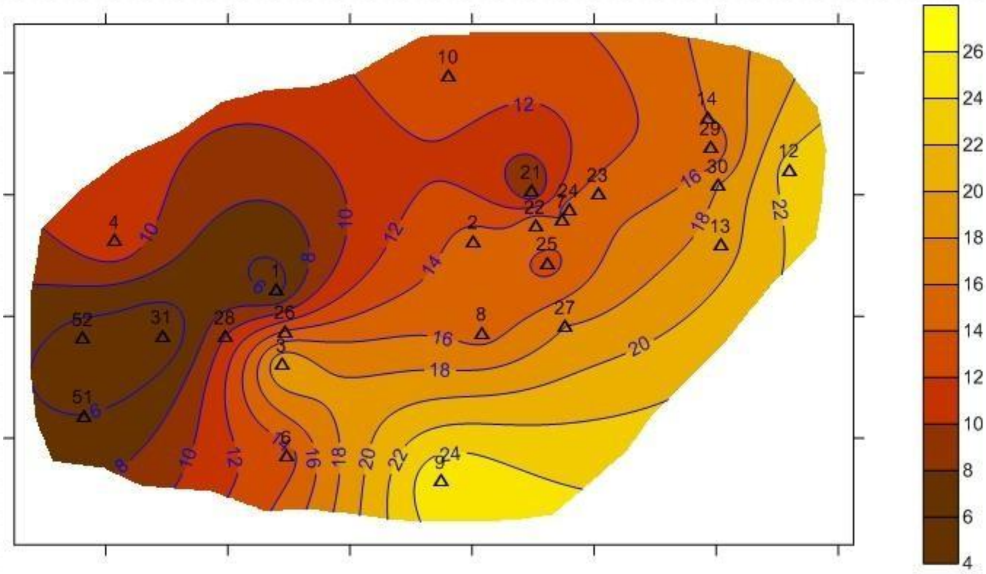

Figure 2: *Gross thickness of the reservoir*

2.1 LOG-SHAPE ANALYSES

Two different interpretations of well-log shapes were applied. One of them, I#1, captured the general vertical trend of the whole reservoir thickness, the second one, I#2, concentrated only to the sandy intervals. In **Figure 3** the interpretations of log-shapes carried out to describe the grain size tendency of the whole thickness. The identified shapes were as follows: bell (green spots), serrated (red spots), funnel (blue spots), and symmetrical (purple spots).

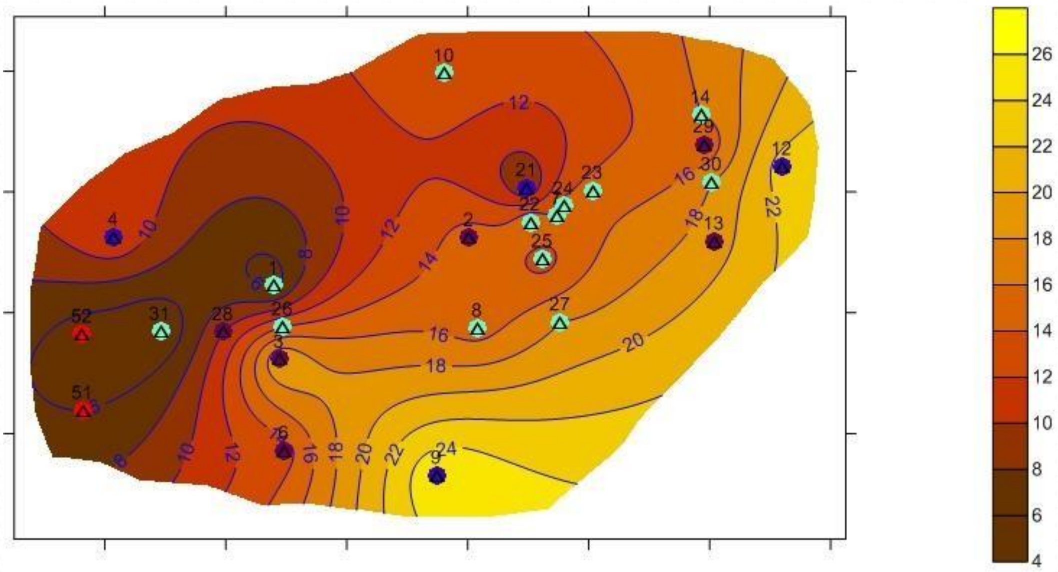

Figure 3: *Map of the identified log shapes in the case of I#1 (Contours are thickness)*

In **Figure 4** the interpretation focused on the shapes of the log curves only in sandy intervals. In this case the following types could be recognized: bell (green spots), serrated (red spots), and funnel (blue spots).

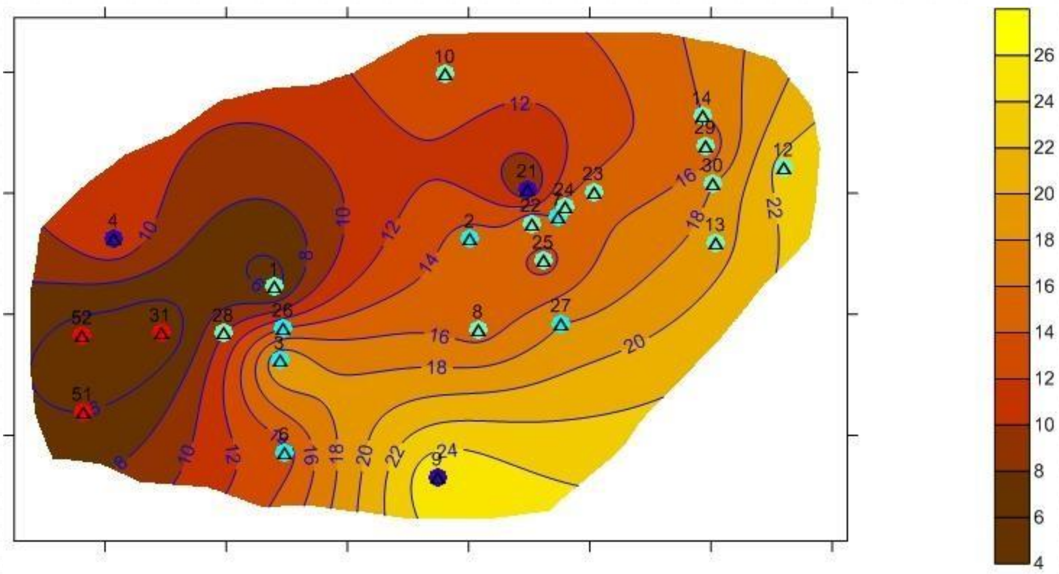

Figure 4: *Map of the identified log shapes in the case of I#2 (Contours are thickness)*

The symmetrical and bell-shapes were merged together. It is worth noting, that the classification was not changed significantly in the eastern part and it almost only concentrated to West side of the rock body. The consequence was that the IK of the log shapes could be expected to give similar results for the eastern part and more different maps for the western part when processing I#1 and I#2.

The bell-shapes appeared within the medium thickness part of the reservoir and their presence was noticeable where the thickness started to increase abruptly. Their thickness varied between 14 and 18 m. The serrated-shapes were detected only three wells which were connected to the thinnest part on the West side of the area. The funnel-shapes appeared randomly through the reservoir (**Figure 4**).

On the basis of turbidity genetics of this rock body, the bell shapes showing fining upward sequence could be incorporated with channels on the fan. Funnel shapes representing coarsening upward sequences could be connected belonged to fan lobes. The serrated shapes without any trends were associated with the aggradations of the shale and silt in abyssal and sea-floor plain.

2.2 INDICATOR KRIGING

Indicator kriging is a non-parametric method of interpolation to estimate the local conditional probability distributions by using some pre-defined threshold value. In this case this method was used the three categorical variables representing the three log-shapes. That is why the result showed the probability of appearing each shapes at grid points. The purpose of this step was to reveal the possible lateral connection of each variable.

In the IK process, the first step was the definition of three indicator variable one for each log-shape. Then the experimental indicator variograms were modelled using some permissible theoretical functions. The final estimation of multi-variable indicator function occurred by full IK within the frame of WinGSLIB (Deutsch and Journel, 1997).

3 RESULTS AND INTERPRETATIONS

IK was applied for both well log-shape analysis approaches (I#1 and I#2). In the interpretation of the results the main emphasize was given to the lateral distribution of bell-shapes since: (1) the geometry of the isolines could be evidenced the presence of channels; (2) only a few points were belonged to funnels and serrated-shapes which did not show any significant spatial relation. **Figure 5-6** showed the results for both I#1 and I#2 analysis.

The shapes of contours belonging to $p>0.8$ probabilities are very similar in the eastern side on both maps. **Figure 5**. shows a possible distributary channel geometry that can also be recognized on **Figure 6** with the same probability, but with a bit different geometry. The negligible difference was probably caused by the different ranges of the two indicator semivariograms. It was resulted in the disappearing of the typical channel geometry in **Figure 6**.

In **Figure 7** the lithology ratio (blue isolines) is shown along with the lithology number (red isolines). This map points out where the channels and lobes approximately can be expected. The lithology ratio expresses how many percent was occupied by sand from the total thickness. The high ratio could be incorporated with channels and lobes.

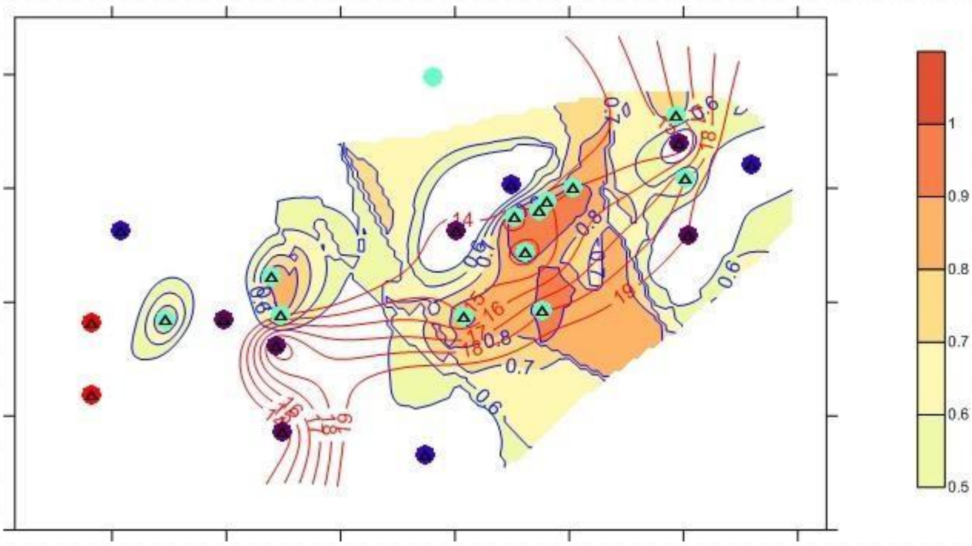

Figure. 5: *IK map of the first well-log shape analysis (I#1). For explanation see the text.*

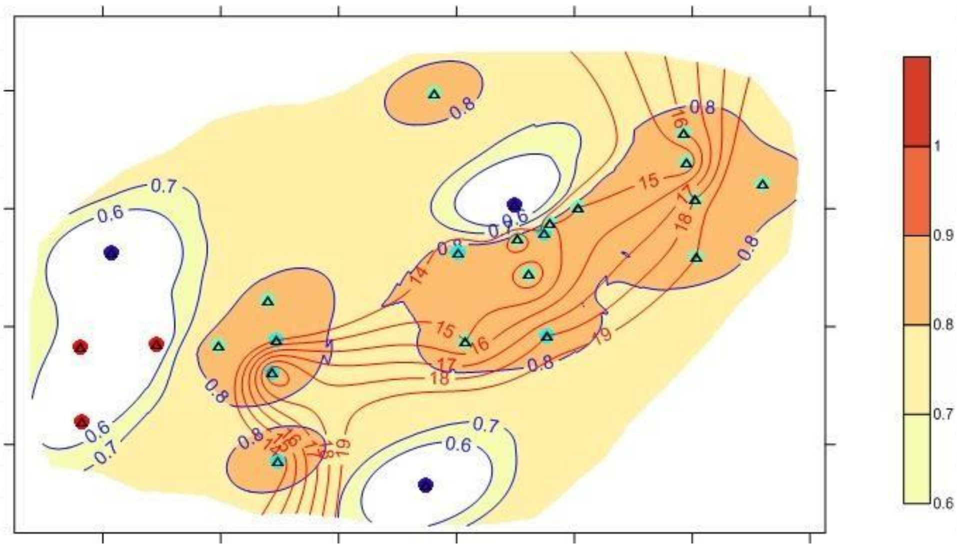

Fig. 6: *IK map of the second well-log shape analysis (I#2). For explanation see the text.*

In theory the lithology number gradually increases from the proximal side toward the distal side of the lobe (in downstream direction). **Figure 7** suggests those regions where the lithology ratio decreases and the simultaneously the lithology number increases toward the South and Southeast directions.

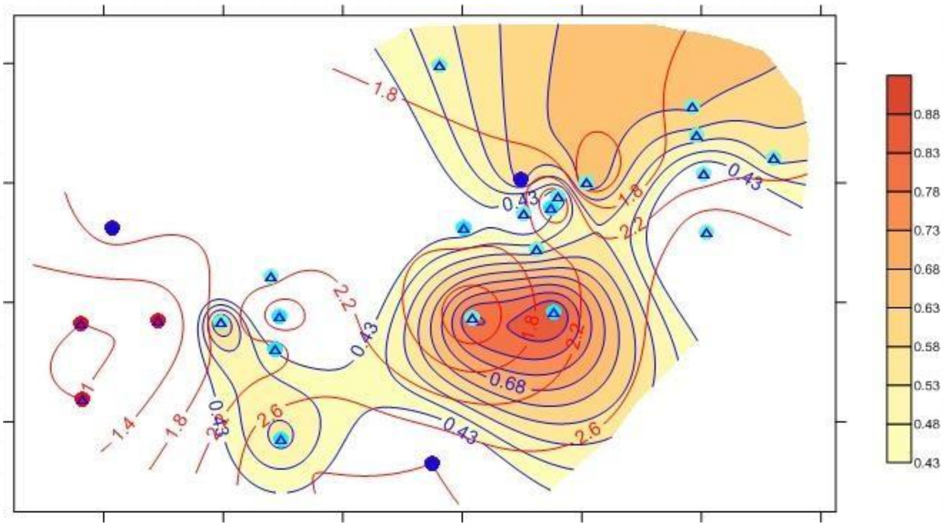

Figure. 7: *Lithology ratios and lithology numbers*

Finally, **Figure 5-7** have proved that lob-channels could be connected to the center of the studied are, while lobe could be expected withing the South and Southeast side of the rock body. The lateral distributions of the available wells do not allow to extend this result to the North and Northeast.

4 DISCUSSION

In the analysis of this rock body many evidences suggested that the depositional environment could be identified as a Mud/Sand-Rich Ramps *(***Figure 8***).* They were as follows: (1) deformation structures caused by slumping in Well 14; (2) sedimentary structures of channel successions in Well 25; (3) a possible distributary channel geometry around Well 25; in the IK map of **Figure 5** (4) the IK of the second interpretation *(***Figure 6***)* indicated the same channels location on the eastern side with the same probability; (5) the lithology ratio did not exceed 0.7 which could be achieved in Sand-Rich Ramp setting (Richards, 1994); (6) the thickness was increased abruptly from 12 meters and it could be identified as proximal or medial ramp.

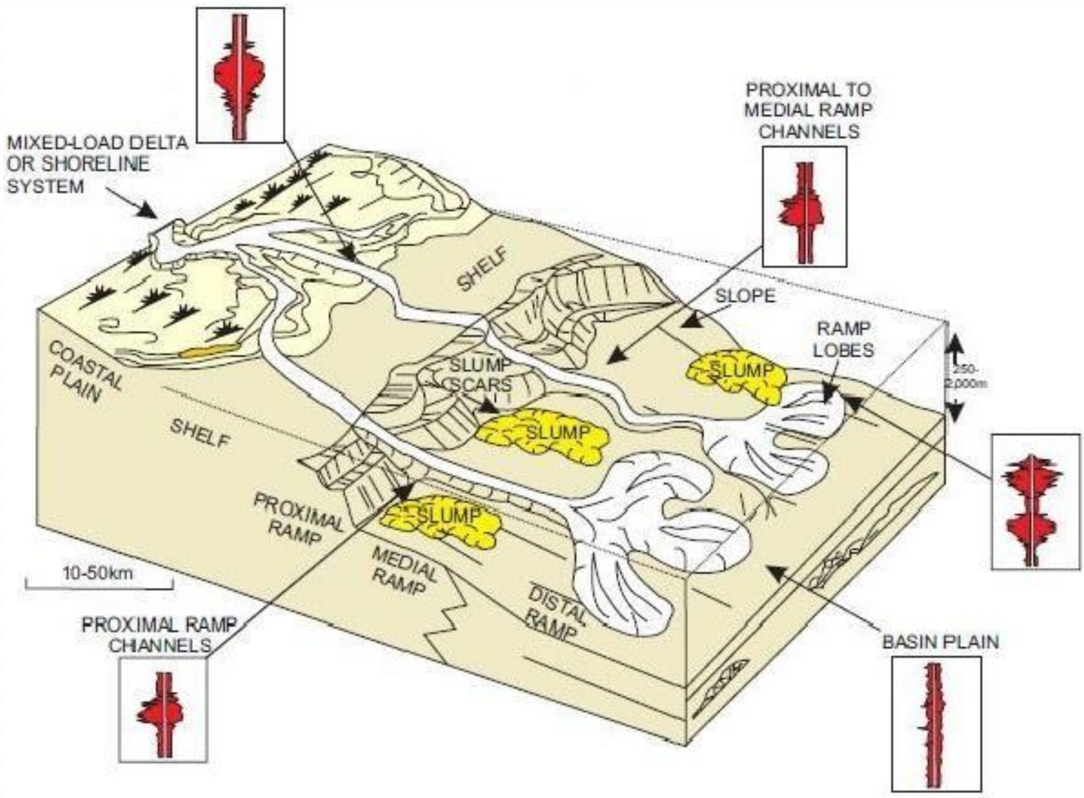

Figure. 8: *Mud/Sand-Rich Ramps (after Harold; Richards 1994)*

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